Password patterns analysis

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1 Introduction

For every analysis in this document, we take passwords from RockYou password list, which users used at least 3 times.

(`https://wiki.skullsecurity.org/Passwords`) After that we filtered passwords that match a particular pattern.

Cracklib and PassWDQC library gives us output, OK or reason why the password was rejected.

Pwscore returns reason of rejection or password score, this score is in range from 0 to 100, passwords with a score higher than 39 are consider as OK.

Zxcvbn-Python, Zxcvbn-C and Passfault works same as Pwscore, but with a different range of score. Zxcvbn-Python return score in range from 0 to 4, passwords with score 3 and 4 are OK. For Zxcvbn-C the range of score is between 0 and 100, we set threshold to 33. For Passfault library we choose threshold with value 100000000000.

2 Results

In the first analysis we take passwords that contain a 'space' character. We found out that around 90% of these passwords are accepted by CrackLib library. The most interesting thing is that when password contain only white characters, Passfault library returned high value of password score(total-cost), so the password was considered as secure one.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	2284 (90.17%)	249 (9.83%)
PassWDQC	372 (14.69%)	2161 (85.31%)
Passfault	593 (23.41%)	1940 (76.59%)
Pwscore	1284 (50.69%)	1249 (49.31%)
ZxcvbnC	610 (24.08%)	1923 (75.92%)
ZxcvbnPython	1087 (42.91%)	1446 (57.09%)

Table 1: Number of rejected/accepted passwords

Password	Length	CrackLib	Passfault
rock you	8	OK	Rejected
love you	8	OK	Rejected
i rock	6	it is based on a dictionary word	Rejected
'white characters'	15	OK	OK (9.223372036854776e+18 score)
harry potter	12	OK	Rejected

Table 2: Password examples

Next analysis contains passwords that contain letter, number, special character, are longer than 9 characters and have at least 7 different characters. Around 50% of these passwords are accepted by every password checking library.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	1341 (57.19%)	1004 (42.81%)
PassWDQC	1519 (64.78%)	826 (35.22%)
Passfault	845 (36.03%)	1500 (63.97%)
Pwscore	1255 (53.52%)	1090 (46.48%)
ZxcvbnC	798 (34.03%)	1547 (65.97%)
ZxcvbnPython	1095 (46.7%)	1250 (53.3%)

Table 3: Number of rejected/accepted passwords

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
abc123!@#	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected
123abc!@#	Rejected	OK	Rejected	Rejected	Rejected	Rejected
po#34tato	Rejected	OK	OK	Rejected	OK	OK
123abc...	Rejected	OK	Rejected	Rejected	Rejected	Rejected
100%princess	Rejected	OK	Rejected	Rejected	Rejected	Rejected
mymomis#1	OK	Rejected	OK	Rejected	Rejected	OK

Table 4: Password examples

For the next analysis we filtered passwords with pattern represented by regex$\hat{}\,\backslash d\backslash d\,.*\,\backslash d\backslash d\$$. So we take passwords which contain at least 2 digits as prefix and as postfix, and the passwords are longer than 8 characters.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	534 (67.94%)	252 (32.06%)
PassWDQC	12 (1.53%)	774 (98.47%)
Passfault	110 (13.99%)	676 (86.01%)
Pwscore	252 (32.06%)	534 (67.94%)
ZxcvbnC	191 (24.3%)	595 (75.7%)
ZxcvbnPython	374 (47.58%)	412 (52.42%)

Table 5: Password length ≥ 8 characters

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
123princess123	OK	Rejected	Rejected	OK	Rejected	OK
123love456	OK	Rejected	Rejected	OK	Rejected	OK
22Jan5086	OK	OK	Rejected	OK	OK	OK
123password123	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected
20dolly20	OK	Rejected	Rejected	Rejected	OK	OK
12rockyou12	Rejected	Rejected	Rejected	Rejected	Rejected	OK

Table 6: Password examples

In this case we take palindrom passwords. Number of passwords that are accepted by password checking libraries are low, but still some of these password can be considered as weak ones.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	30 (1.01%)	2938 (98.99%)
PassWDQC	0 (0.0%)	2968 (100.0%)
Passfault	33 (1.11%)	2935 (98.89%)
Pwscore	0 (0.0%)	2968 (100.0%)
ZxcvbnC	13 (0.44%)	2955 (99.56%)
ZxcvbnPython	24 (0.91%)	2944 (99.19%)

Table 7: Palindrom passwords

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
asaasaasa	Rejected	Rejected	OK	Rejected	Rejected	Rejected
lol-lol	Rejected	Rejected	OK	Rejected	OK	Rejected
passworddrowssap	OK	Rejected	Rejected	Rejected	Rejected	Rejected
aaannnaaa	Rejected	Rejected	Rejected	Rejected	Rejected	OK
123654789987456321	OK	Rejected	OK	Rejected	Rejected	Rejected

Table 8: Password examples

The next analysis focus on keyboard sequence, which only Passfault library can detect. So we take passwords which Passfault library tag as keyboard sequences only.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	108 (9.29%)	1054 (90.71%)
PassWDQC	1 (0.09%)	1161 (99.91%)
Passfault	0 (0.00%)	1162 (100.0%)
Pwscore	59 (5.08%)	1103 (94.92%)
ZxcvbnC	11 (0.95%)	1151 (99.05%)
ZxcvbnPython	86 (7.4%)	1076 (92.6%)

Table 9: Number of rejected/accepted passwords

The results are quite good, but as you can see in the table below, there are passwords with really basic patterns e.g. 123 postfix/prefix or another digit sequences.

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
123Leigh456	OK	OK	Rejected	OK	Rejected	OK
123hello123	OK	Rejected	Rejected	OK	Rejected	Rejected
12prision12	OK	Rejected	Rejected	OK	OK	OK
12liverpool12	Rejected	Rejected	Rejected	Rejected	Rejected	OK

Table 10: Password examples

Now we filtered passwords that contain a word and a digit sequence '123' as postfix.

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
strawberry123	OK	Rejected	Rejected	OK	Rejected	Rejected
AaBbCc123	Rejected	OK	OK	Rejected	Rejected	Rejected
mynameis123	OK	Rejected	OK	OK	Rejected	Rejected
asdfghjkl123	OK	Rejected	Rejected	OK	Rejected	Rejected
yahoo.com123	OK	OK	OK	OK	OK	OK
ilovepink123	Rejected	Rejected	Rejected	Rejected	Rejected	OK

Table 11: Password examples

In the tables below are overall results.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	4052 (25.04%)	12127 (74.96%)
PassWDQC	31 (0.19%)	16148 (99.81%)
Passfault	119 (0.74%)	16060 (99.26%)
Pwscore	1412 (8.73%)	14767 (91.27%)
ZxcvbnC	51 (0.32%)	16128 (99.68%)
ZxcvbnPython	963 (5.95%)	15216 (94.05%)

Table 12: Number of rejected/accepted passwords

Password checking library	Accepted passwords	Rejected passwords
CrackLib	4052 (40.28%)	6008 (59.72%)
PassWDQC	30 (0.3%)	10030 (99.7%)
Passfault	119 (1.18%)	9941 (98.82%)
Pwscore	1412 (14.04%)	8648 (85.96%)
ZxcvbnC	51 (0.51%)	10009 (99.49%)
ZxcvbnPython	963 (9.57%)	9097 (90.43%)

Table 13: Number of rejected/accepted passwords longer than 8 characters

For the next analysis we take passwords with a email address pattern, represented by regex as $\hat{}.+\backslash@.+\backslash..+\$$. The results are that every password checking library accepted these passwords in almost 100% cases, only passwords which are shorter were rejected.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	33 (100.0%)	0 (0.0%)
PassWDQC	32 (96.97%)	1 (3.03%)
Passfault	33 (100.0%)	0 (0.0%)
Pwscore	32 (96.97%)	1 (3.03%)
ZxcvbnC	32 (96.97%)	1 (3.03%)
ZxcvbnPython	33 (100.0%)	0 (0.0%)

Table 14: Number of rejected/accepted passwords

Password	CrackLib	PassWDQC	Passfault	Pwscore	ZxcvbnC	ZxcvbnPython
joe@somebody.com	OK	OK	OK	OK	OK	OK
tstewartbug@hotmail.com	OK	OK	OK	OK	OK	OK
me@me.com	OK	Rejected	OK	Rejected	Rejected	OK
love@yahoo.com	OK	OK	OK	OK	OK	OK
crowwamy77@yahoo.com	OK	OK	OK	OK	OK	OK

Table 15: Few password examples

For the last analysis, we take all passwords from RockYou that were used at least 3 times by users and reverse these passwords. The tables below shows results how many passwords are rejected/accepted before and after this transformation. In all cases except Passfault library the results are almost similar.

Password checking library	Accepted passwords	Rejected passwords
CrackLib	256753 (22.6%)	879390 (77.4%)
PassWDQC	3189 (0.28%)	1132954 (99.72%)
Passfault	20057 (1.77%)	1116086 (98.23%)
ZxcvbnC	25860 (2.28%)	1110283 (97.72%)
ZxcvbnPython	69630 (6.13%)	1066513 (93.87%)

Table 16: Before transformation

Password checking library	Accepted passwords	Rejected passwords
CrackLib	256762 (22.6%)	879381 (77.4%)
PassWDQC	6751 (0.59%)	1129392 (99.41%)
Passfault	213725 (18.81%)	922418 (81.19%)
ZxcvbnC	30385 (2.67%)	1105758 (97.33%)
ZxcvbnPython	81313 (7.16%)	1054830 (92.84%)

Table 17: After transformation